Commercial Reusable Suborbital
CRuSR
Research Program

Mission Statement:
Facilitate NASA-sponsored researchers, engineers, technologists and educators access to near-space, regularly, frequently, and predictably at reasonable cost with easy recovery of intact payloads

Mike Skidmore
CRuSR Level 2 Program Manager
NASA Ames Research Center

Presentation to:
Next-Generation Suborbital Researchers Conference
Millennium Harvest House Boulder
7 PM, 19 February 2010

Investigator in the NASA Commercial Space Loop (Parabolic Aircraft, CRuSR, ISS/National Lab)

- WHEN:
  - Friday, 19 February, 7:00 p.m. Canyon/Flagstaff
- WHAT:
  - Audience Interactive Panel Discussion
- WHY:
  - NASA is soliciting input from user, provider, regulatory, and commercial infrastructure communities so that it may better support the development and use of a robust and vibrant Commercial Space industrial community

Investigator in the NASA Commercial Space Loop (Parabolic Aircraft, CRuSR, ISS/National Lab)

- WHO:
  - Intended Audience
    - Researchers (Users), Launch Providers, Integrators, Payload Providers, Regulators
  - Panel:
    - **Douglas Comstock**:
      Director, Innovative Partnerships Office
    - **Charles Miller**:
      Senior Advisor for Commercial Space
      Level 1 Manager, CRuSR Program
    - **LtCol Paul Damphousse USMC**:
      National Security Space Office
    - **Michele Brekke**:
      Director, Innovation Partnerships Advanced Planning Office (NASA JSC)
    - **Mike Skidmore**:
      Level 2 Manager, CRuSR Program

Investigator in the NASA Commercial Space Loop (Parabolic Aircraft-FAST, CRuSR, ISS/National Lab)

- Some Topics:
  - How will NASA maximize the use of CRuSR vehicles?
  - Will we do our own manifesting?
  - What are the limits of how we can use funding?
  - Will NASA levy requirements other than those of the user? What documentation will be required?
  - How will liability issues be addressed?
  - Data rights?
  - How will launch readiness be decided?
  - Will NASA involvement extend beyond NASA-only payloads?
  - How will NASA help the development of Commercial Space
  - Will there be standards for interfaces and services across providers?
  - Will it be a turnkey service?
  - How much involvement will I have in the process, launch, recovery, turnaround?
  - How late can I access the vehicle for late load?
  - How quickly will I receive my samples after flight?
  - And more ……

Why is NASA Involved in Commercial Space

- Low-Cost and Reliable Access to Space (LCRATS)
- Similar needs for many complex experiments
  - Late load
  - Controlled environmental conditions on orbit
  - Rapid Payload recovery
  - Benign shock and "g" loads during recovery
  - Mission design favorable to research imperatives
  - Ability to interact with experiment while in orbit
  - Ability to quickly iterate on successive flights

Why is NASA Involved & What is CRuSR?

"…the Commercial Reusable Suborbital Research program… will buy space transportation services from the emerging reusable spaceflight companies to conduct science research, technology development, with a keen focus on education."

Remarks by NASA Administrator Charles Bolden
at the National Association of Investment Companies Washington, DC; 20 Oct 2009

- CRuSR Goals
  - Buy space transportation services from emerging reusable spaceflight companies to conduct science research, technology development, and exploit enormous educational potential of spaceflight
  - Engage the scientific, technical, and educational (user) community to encourage and promote the use of this new opportunity to access Near-Space as a way to inspire "…the next generation of Americans to once again seek become interested in math, science, engineering, and technology so that our nation can maintain its technological leadership in the world"

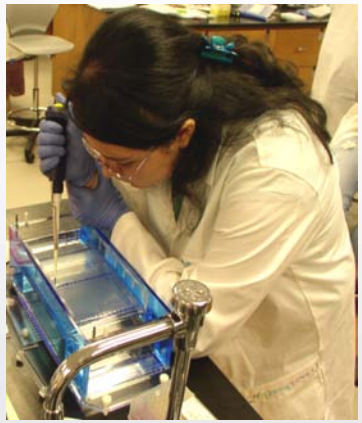
    (Bolden, National Association of Investment Companies)
  - Be a Pathfinder to facilitate user access to near-space by supporting development, integration, and flight of the maximum number of scientific payloads on all available commercial reusable suborbital vehicles

CRuSR Activities: FY2010

- Organize Level 2 Program Office
- Work with NASA science, technology, & education programs to identify spaceflight research payload candidates (users)
- Work with payload providers to characterize each vehicle's Suborbital Flight Environment (Acceleration, quality of μG, etc.)
- Work within NASA,with the FAA, and other regulatory agencies to facilitate safe and effective access to Near-Space
- Facilitate the operations of a commercial payload development/integration industry that will work to move experiments safely and effectively from the laboratory onto Near-Space platforms
- Work with users & industry to identify areas where NASA can best focus our resources (support relevant meetings and conferences)
- Develop procurement strategy to buy space transportation services
- Work to identify and transfer NASA technologies needed by Near-Space Industry (launch providers, payload developers, payload integrators, etc.)

An Opportunity to Really Engage Students

- Rapid access and flight flexibility fits with academic timelines of university students, graduate research, degree cycles, publishing goals
- Partially replaces lost opportunities for low-cost flight engineering and science research experience (e.g. GASCAN in orbiter bay)
- Provides low-risk science/tech assessment and proof of concept for future larger, longer-duration more costly research programs (DragonLab, ISS)
- Possibilities:
  - 1, 10, 25 kg payloads as ballast for other payloads
  - Payloads can hitch rides when margins allow
  - "Pocket payloads" option when deemed safe
  - Student analysis/processing of video data



Suborbital Flight Environmental Monitor (SFEM)

Suborbital Flight Environmental Monitor (SFEM)

- CRuSR must establish the environmental conditions that the research payloads and future passengers will be exposed to during the flights and the pre- and post-flight handling, so that researchers can select the best platform for their experiments and payload developers can design the equipment to perform successfully throughout the mission
- To accomplish this the CRuSR Program Level II office intends to develop or procure Suborbital Flight Environmental Monitors (SFEMs) and fly them on each of the flight providers' vehicles
- Initially, the SFEM should monitor the following parameters:
  - Time,
  - G loads – from 10-6 to 10s of G's
  - Vibration (launch, recovery, handling)
  - Followed shortly by:
    - Quality of micro G
    - Temperature
    - Atmospheric Pressure

CRuSR Procurement

CRuSR Procurement Strategy Development

- Develop a procurement strategy to implement the Administrator's direction to "buy space transportation services from the emerging reusable spaceflight companies "
  - RFI issued 04 Dec 2009
    - contemplating two significant procurement actions:
      - 1) potential procurement of reusable suborbital spaceflight services
      - 2) solicitation of research investigations
  - RFI Modification 01 - Posted on Dec 18, 2009
    - Clarified methods for response to RFI
  - RFI Modification 02 - Posted on Feb 05, 2010
    - "Some responses to the initial request were marked Proprietary or Confidential which prevents NASA from sharing the data received with the research community and which also makes it very difficult to solicit research proposals tailored to the vehicle platforms.

Responses to RFI Mod#2 (as of 18 Feb 2010)

- Blue Origin
- DreamSpace
- Masten Space Systems
- Space-X
- TGV Rockets
- Virgin Galactic
- XCOR Aerospace
- zero2infinity

Airborne Research Model

- Relies on aircraft catalog
  - Commercial companies that replied to an RFI for NASA aircraft services and provided:
    - Flight profiles, pitch & roll rates, angle of attack, yaw, speed, etc, plus environmental information like the pressure, temp, humidity, G's, vibration, and airflow ...incl. the boundary layer (for in situ measurements)
- Each company must pass a NASA Airworthiness Flight Safety Review Board for their aircraft, modifications, pilot qualifications and maintenance practices before officially selecting them for the NASA Airborne Science Catalog
- BPA established with these companies
- Science PI picks one of these aircraft and submits a Flight Request into Earth Science Project Office's (ESPO, http://www.espo.nasa.gov/) database
  - HQ funding approval required
- Company performs the actual integration of the sensor
  - payload must first pass a NASA Flight Readiness Review
- Knowing the characteristics of the aircraft is vital for the PI to design and build the instrument properly in order to:
  - Pass a Critical Design Review
  - Pass NASA Technical Readiness Reviews
  - Gather good science data

CRuSR Safety

CRuSR Safety Overview

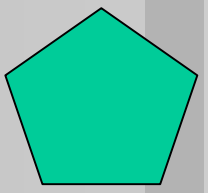
- NASA does not have the authority to certify the airworthiness of Commercial Reusable Suborbital vehicles. That authority resides with the FAA.
- There are, as yet, no specific Human Safety Rating requirements for CRuSR an no immediate plans for NASA to sponsor human participation on CRuSR vehicles
  - There is a directive from NASA management that DFRC will be responsible for developing a process to assess the safety for NASA sponsored participants on CRuSR vehicles. This process is to be modeled after the High-Speed Experimental Aircraft requirements that have been in use at DFRC for many years.
- The CRuSR Human Safety Process will not be modeled after STS or ISS Human Safety requirements.
- CRuSR is not involved in any way with the COTS Human Safety Requirements (SpaceX, Orbital, etc.).
- CRuSR will not be involved in the safety process for non-NASA spaceflight participants on Commercial Reusable vehicles. That authority resides with the FAA.

CRuSR - NASA Safety Overview

- CRuSR payloads must safely integrate and operate in the Commercial Reusable Suborbital launch vehicles and they must not present hazards for the Human crew and passengers (if present)
- CRuSR is required to develop a safety process for payloads and a separate process to ensure that the risks for any NASA sponsored Human participants are well understood and are acceptable to NASA.
  - **Payload safety** (is the payload safe for flight)
    - Ames Research Center
    - Safe for human passengers & crew
    - Safe function = non-hazardous to vehicle
    - Non-interference
      - With vehicle
      - With other payloads
  - **Human safety** (is the flight environment safe)
    - Dryden Flight Research Center
    - Process based on High-Speed Experimental Aircraft
    - Includes all aspects of payload safety
    - Vehicle safety and reliability

CRuSR Payload Safety Overview

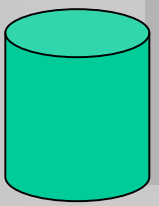
- Commercial Space Safety has 2 separate tracks
  - Government owned and operated



Government Owned and Operated Payload

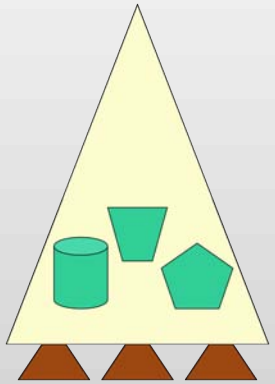
- Government Assurance of:
  - Safety
  - Functionality
  - ICD compliance
  - Integration processes

  - Privately owned and operated



Privately Owned and Operated Payload

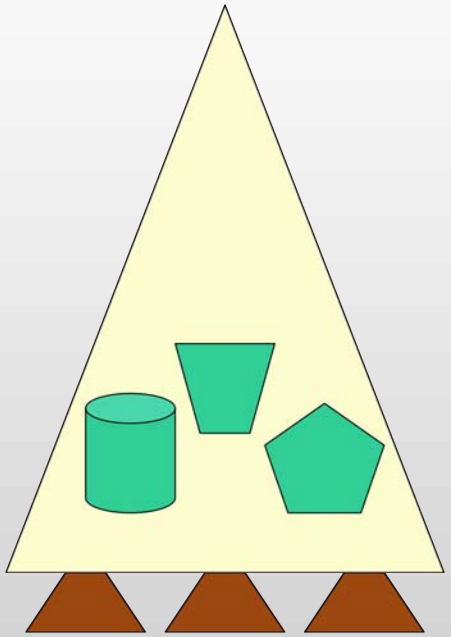
- Commercial Assurance of:
  - Safety
  - Functionality
  - ICD compliance
  - Integration processes
  - ***FAA Regulatory Compliance***



Flight

Commercial Reusable Suborbital - Payload Safety

- Traditional NASA Payload Safety Analysis for NASA payloads on NASA vehicles
  - Vehicle interfaces
  - Individual Payloads
  - Interactions between vehicle and payloads
  - Interactions between payloads
- Who performs this analysis for Commercial Launches
- Launch Provider carries ultimate responsibility for safety and function
- Launch Providers (and their insurers) will need to have some level of insight into all payloads (even proprietary research)
- Who serves this function
  - Third party bonded payload integrators?



CRuSR Needs Your Help

"… America needs NASA and private industry to work to achieve our national goals in space. This means that NASA must determine efficient and effective ways to leverage the power, and innovation of American industry and the American entrepreneur."

"Help us determine how we can create a more effective partnership between the genius of the American entrepreneur and the power of the federal government."

Remarks by NASA Administrator Charles Bolden
at the National Association of Investment Companies Washington, DC; 20 Oct 2009

- *CRuSR is soliciting input from user, provider, regulatory, and commercial infrastructure communities so that it may better support the use and development of a robust and vibrant Near-Space industrial community*

CRuSR

"Do what you can, with what you have, where you are"
Theodore Roosevelt

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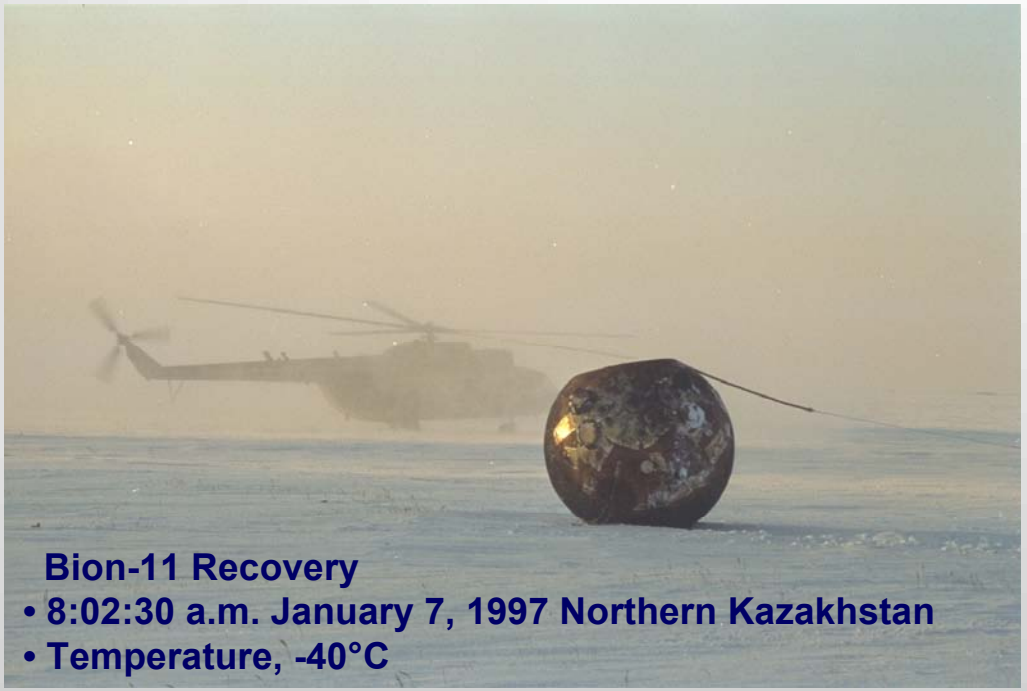
I Hope There Are Lots of Questions?

Backup >>>

"The perfect is the enemy of the good."

"Le mieux est l'ennemi du bien." Voltaire: *Dictionnaire Philosophique* (1764)

- Every scientific payload must be adapted to the specific spaceflight "system"
  - Space Shuttle - CEV - ISS
  - Orbital Free-flyers
    - Commercial
      - DragonLab
    - Foreign
    - SmallSat
    - NanoSat
  - Expendable Near-Space
  - **Reusable Near-Space**

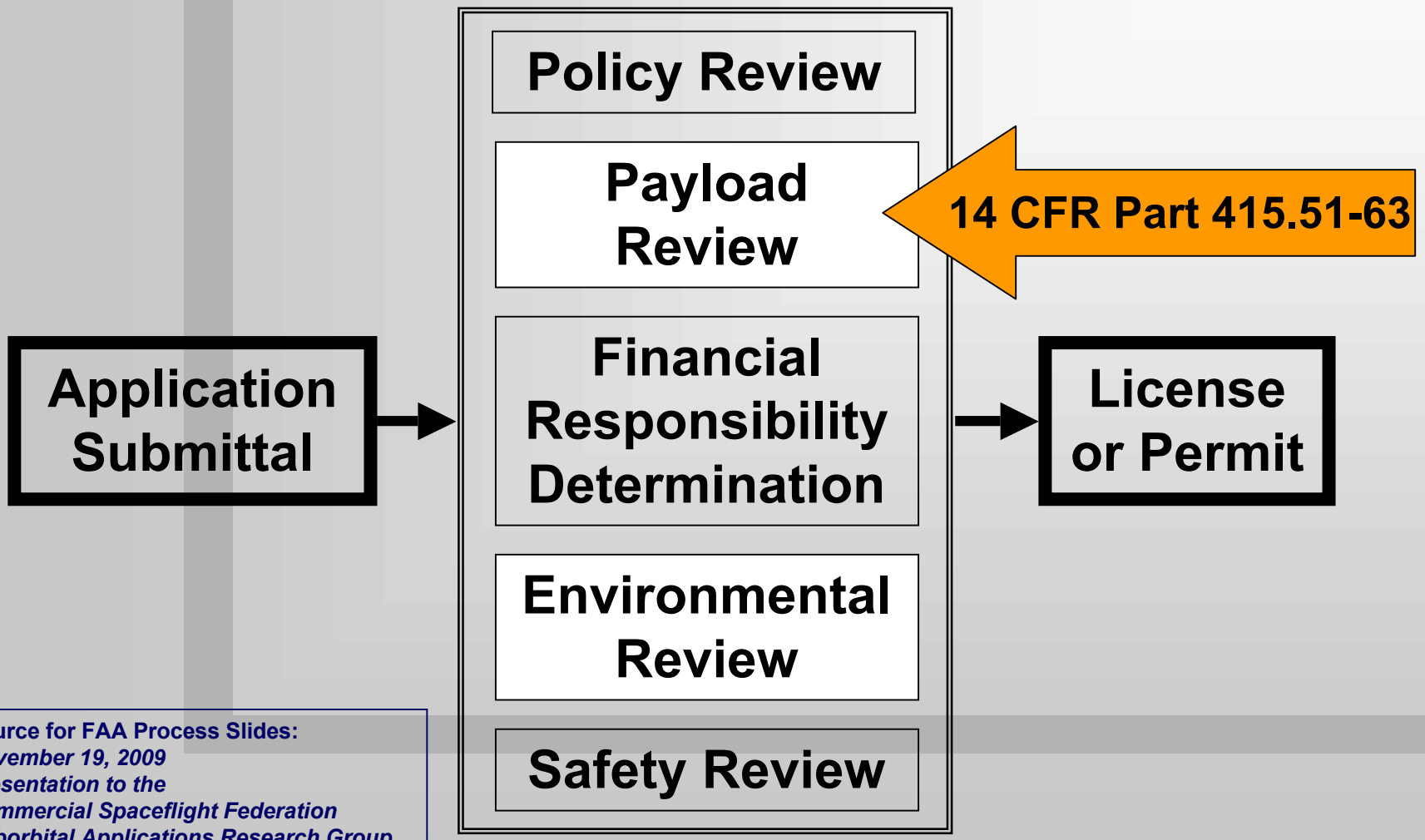


Bion-11 Recovery
• 8:02:30 a.m. January 7, 1997 Northern Kazakhstan
• Temperature, -40°C

- Co-manifested payloads must not interfere with each other
- The Mission/Project Managers job is to get the mission launched while ensuring the maximum scientific return

The goal is publishable scientific data

Licensing / Permitting Process Flow
FAA-AST Reviews, Approvals, and Determinations



Source for FAA Process Slides:
November 19, 2009
Presentation to the
Commercial Spaceflight Federation
Suborbital Applications Research Group
Ken Davidian
EFP Program Lead

FAA Payload Process Flow

- The FAA reviews a payload proposed for launch or reentry to *determine whether a license applicant or payload owner or operator has obtained all required licenses, authorizations, and permits, unless the payload is exempt from review*.
- Each payload is subject to compliance monitoring by FAA before launch, unless otherwise exempt.

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Is My Payload Exempt?

- **You Are Exempt If…**
  - … your payload is subject to the regulation of the FCC or DoC/NOAA.
  - … your payload is owned and operated by the government of the United States.
- **If You Are Not Exempt…**
  - … A payload review may be requested as part of a license application review.
  - … A payload review may be requested by the payload owner in advance of or apart from a license application.

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Payload Review Details

- Why Information is Required
  - To identify and address possible safety and policy issues related to the payload.
  - To conduct any necessary interagency review.
- Who Conducts the Payload Review
  - The FAA coordinates a payload review with other gov't agencies (DoD, DoS, DoC, NASA, FCC, etc.)
- Considerable detail may be necessary for cases which present potential unique safety concerns.
  - Payload physical characteristics, functional description, operations
- The FAA will issue a payload determination unless policy or safety considerations prevent launch of the payload.

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Payload Review Info Required

- Payload name
- Payload class
- Physical dimensions and weight of the payload
- Payload owner and operator, if different from the person requesting payload review
- Orbital parameters for parking, transfer and final orbits
- Hazardous materials
- Intended payload operations during the life of the payload
- Delivery point in flight at which the payload will no longer be under the licensee's control

Source: 14 CFR 14 §415.59 Information requirements for payload review.

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Commercial Reusable Suborbital Developers

A sample of those who have flown and aspire to Near-Space

Virgin Galactic - Scaled

Blue Origin

XCOR

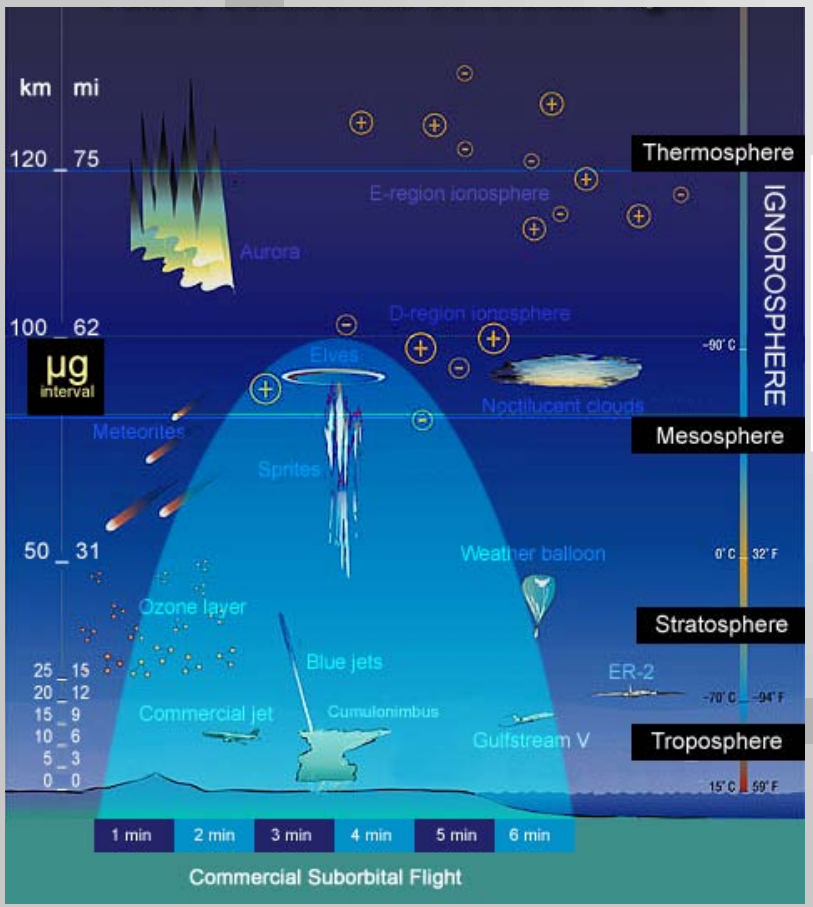
Armadillo Aerospace

Masten Space Systems

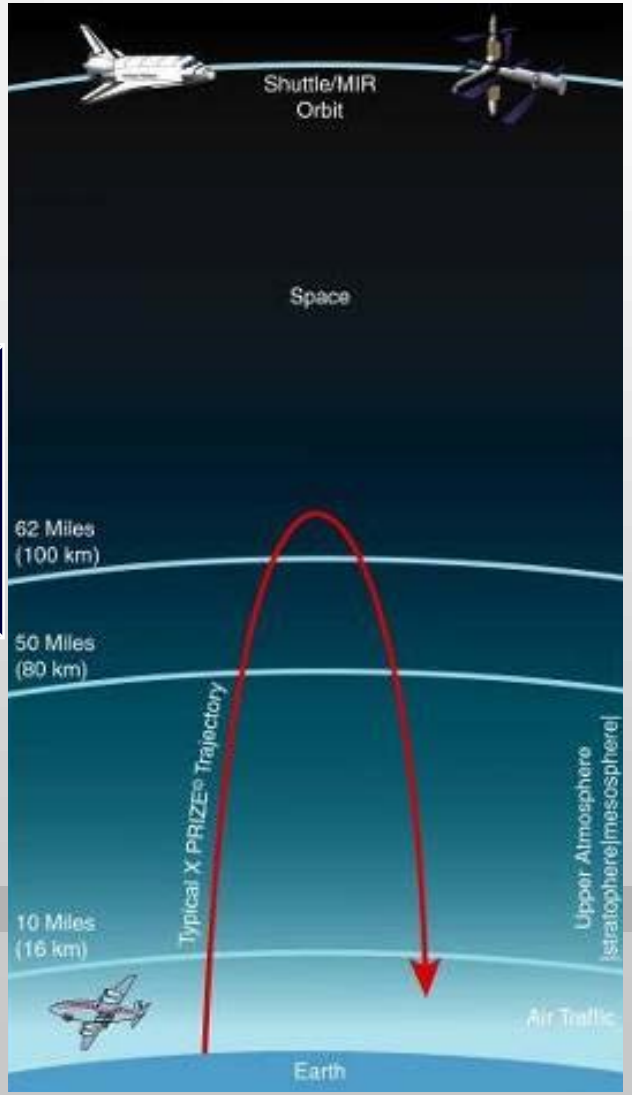
- Horizontal & vertical launch & recovery options
- From 0-6 passengers
- From 0-3 crew
- First full-up test flights in late 2010

Near-Space?

Commercial Reusable Suborbital Flight
- Nominal 3-6 minutes micro-G
- Access to "ignorosphere"



- too low for orbital spacecraft
- too high for aircraft / balloons



Technology Maturation

- "Build a little; test a lot" development process
  - Fly cheaply, frequently and often
  - Take risks
    - Try options and learn from mistakes/failures
    - Explore far-out concepts
- Develop standard operations and procedures, e.g.:
  - Systems health management and maintenance
  - Configuration management of software that "learns"
  - First aid or medical procedures in microgravity
- Learn the cost of development and implementation
  - How much time does it take to design and implement a certain technology?
  - What can go wrong?
  - Can the process be improved?

CRuSR Near-term Objectives

- Educate the scientific, technological, & educational (user) community about the opportunities presented by this new access to space
- Facilitate user access to Near-Space through the emerging Commercial Reusable Suborbital community
- Work with FAA and other regulatory agencies to facilitate safe and effective access to Near-Space
- Facilitate the operations of a commercial payload integration industry that will work to move experiments safely and effectively from the laboratory onto Near-Space platforms
- Work to transfer NASA technologies and processes critical to the transition of experiments from laboratories onto Near-Space platforms

CRuSR Near-term Objectives (cont)

- Work with established spaceports to encourage commercial activities that facilitate the growth of suborbital space research
- Work with government (DoD, other agencies) and industry to leverage resources across the R&D community to develop access to Near-Space
- Work with government's administrative infrastructure to define strategies and approaches that facilitate research access to Near-Space
- Engage education community to integrate their expertise and creativity into Near-Space research so integration of Scientific, Technical, Engineering, and Mathematical (STEM) educational assets and Near-Space are mutually beneficial and self-sustaining

CRuSR Near-term Objectives (cont)

- Facilitate development of open interactive websites where:
  - Research community can exchange information and ideas to facilitate development of an active and knowledgeable user community
  - Launch provider community can share information to develop common community responses to items of interest, develop standard payload interfaces, and communicate capabilities to potential users
  - Broader Near-Space community (launch providers, users, service providers, government) can exchange information and develop innovative collaborations with established spaceports to encourage commercial activities that facilitate the growth of suborbital space research